



• PATENTS • DESIGNS • COPYRIGHT • TRADE MARKS
The Patent Office 10/50730
10 Rec'd PCT/GB03/0065
15 SEP 2004

INVESTOR IN PEOPLE

PRIORITY DOCUMENT

SUBMITTED OR TRANSMITTED IN
COMPLIANCE WITH RULE 17.1(a) OR (b)

The Patent Office
Concept House
Cardiff Road
Newport
South Wales
NP10 8QQ

I, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of the Deregulation & Contracting Out Act 1994, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of the documents as originally filed in connection with the patent application identified therein.

REC'D 19 MAY 2003

WIPO PCT

In accordance with the Patents (Companies Re-registration) Rules 1982, if a company named in this certificate and any accompanying documents has re-registered under the Companies Act 1980 with the same name as that with which it was registered immediately before re-registration save for the substitution as, or inclusion as, the last part of the name of the words "public limited company" or their equivalents in Welsh, references to the name of the company in this certificate and any accompanying documents shall be treated as references to the name with which it is so re-registered.

In accordance with the rules, the words "public limited company" may be replaced by p.l.c., plc, P.L.C. or PLC.

Registration under the Companies Act does not constitute a new legal entity but merely subjects the company to certain additional company law rules.

Signed

Dated 9 April 2003

Stephen Horrell

Best Available Copy

18NAR02 E704186-1 D03312
P01/7700 0.00-0206246.1

Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form.)

The Patent Office

 Cardiff Road
Newport
South Wales
NP9 1RH

1. Your reference

RPH.P51444GB

0206246.1

2. Patent application number

(The Patent Office will fill in this part)

15 MAR 2002

3. Full name, address and postcode of the or of each applicant (underline all surnames)

 Weatherford/Lamb, Inc.
515 Post Oak Blvd., Suite 600
Houston
Texas 77027
USA

Patents ADP number (if you know it)

USA

8028714.001

If the applicant is a corporate body, give the country/state of its incorporation

4. Title of the invention

"Tractors for Movement along a Pipeline within a Fluid Flow"

5. Name of your agent (if you have one)

Marks & Clerk

"Address for service" in the United Kingdom to which all correspondence should be sent (including the postcode)

 4220 Nash Court
Oxford Business Park South
Oxford OX4 2RU
United Kingdom

Patents ADP number (if you know it)

7271125001

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and (if you know it) the or each application number

Country

Priority application number
(if you know it)Date of filing
(day / month / year)

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application

Date of filing
(day / month / year)

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? (Answer 'Yes' if:

Yes

- a) any applicant named in part 3 is not an inventor, or
- b) there is an inventor who is not named as an applicant, or
- c) any named applicant is a corporate body.

See note (d))

Patents Form 1/77

9. Enter the number of sheets for any of the following items you are filing with this form.
Do not count copies of the same document

Continuation sheets of this form

Description

6

Claim(s)

4 *DM*

Abstract

1

Drawing(s)

2 only

10. If you are also filing any of the following, state how many against each item.

Priority documents

Translations of priority documents

Statement of inventorship and right to grant of a patent (Patents Form 7/77)

Request for preliminary examination and search (Patents Form 9/77)

1

Request for substantive examination (Patents Form 10/77)

Any other documents
(please specify)

11. I/We request the grant of a patent on the basis of this application.

Signature *Marks & Clerk* Date

15 March 2002

12. Name and daytime telephone number of person to contact in the United Kingdom

Richard Harding
(01865) 397900

Warning

After an application for a patent has been filed, the Comptroller of the Patent Office will consider whether publication or communication of the invention should be prohibited or restricted under Section 22 of the Patents Act 1977. You will be informed if it is necessary to prohibit or restrict your invention in this way. Furthermore, if you live in the United Kingdom, Section 23 of the Patents Act 1977 stops you from applying for a patent abroad without first getting written permission from the Patent Office unless an application has been filed at least 6 weeks beforehand in the United Kingdom for a patent for the same invention and either no direction prohibiting publication or communication has been given, or any such direction has been revoked.

Notes

- a) If you need help to fill in this form or you have any questions, please contact the Patent Office on 0645 500505.
- b) Write your answers in capital letters using black ink or you may type them.
- c) If there is not enough space for all the relevant details on any part of this form, please continue on a separate sheet of paper and write "see continuation sheet" in the relevant part(s). Any continuation sheet should be attached to this form.
- d) If you have answered 'Yes' Patents Form 7/77 will need to be filed.
- e) Once you have filled in the form you must remember to sign and date it.
- f) For details of the fee and ways to pay please contact the Patent Office.

DUPLICATE

"Tractors for Movement along a Pipeline within a Fluid Flow"

5 This invention relates to tractors for movement along a pipeline within a fluid flow along the pipeline. The term "tractor" is used in this specification to denote any type of pig, tractor or other device for movement along pipeline within a fluid flow.

10 In the oil and gas exploration and extraction industry, there is widespread use of subsurface and subsea conduits, often of extended lengths. For example subsea pipelines may extend for many kilometres between subsea wellheads and support platforms, and between production platforms and onshore facilities. Over time, there tends to be build-up of material on the inner walls of such pipelines which may include wax, scale and various precipitates. Of course, such a build-up of material will reduce the flow capacity of the pipeline, and may result ultimately in the pipeline becoming 15 blocked.

20 Conventionally such pipelines are periodically cleaned by passing a pig through the pipeline, with the pig being launched into the pipeline at an appropriate upstream point, which may require production to be temporarily stopped. A pig is typically of cylindrical form, of slightly smaller diameter than the pipeline, and is carried through the pipeline by the flow of fluid in the pipeline. Dislodged material therefore builds up in front of the pig, and it is accordingly not unusual for pigs to become stuck in pipelines, which may bring production to a halt. Retrieval of a stuck pig requires the pig to be located, the pipeline opened to remove the pig, and the pipeline reinstated, 25 which is both an expensive and difficult undertaking.

30 It is an object of the invention to provide a tractor for movement along a pipeline within the fluid flow along the pipeline which renders it less likely that material will build up within the pipeline in such a manner as to block the passage of the tractor along the pipeline.

According to one aspect of the present invention there is provided a tractor for movement along a pipeline within a fluid flow along the pipeline, the tractor comprising propulsion means propelling the tractor along the pipeline in the direction of the fluid flow at a speed which is not directly related to the speed of the fluid flow.

5

According to another aspect of the invention there is provided a tractor for movement along a pipeline within a fluid flow along the pipeline, the tractor comprising speed regulated propulsion means for propelling the tractor along the pipeline in the direction of the fluid flow at a regulated speed.

10

According to another aspect of the invention there is provided a tractor for movement along a pipeline within a fluid flow along the pipeline, the tractor incorporating a geared braking mechanism for controlling the speed of the tractor along the pipeline in the direction of fluid flow.

15

In a pipeline containing gas or gas and fluid a conventional pig will travel along the pipeline at a variable speed in dependence on variations in the pressure of the gas and/or flow variations caused by slugging of a two-phase flow. By contrast the tractor of the invention travels along the pipeline at a constant and/or controllable speed, and 20 this is beneficial in terms of allowing efficient cleaning of the pipeline (where the device is used for pipeline cleaning) or in regulating the speed of inspection operations (where the device is used for inspection of the pipeline). A tractor travelling at a constant and/or controlled speed is found to be more effective and to achieve better cleaning than a tractor which is propelled along the pipeline at the rate of fluid flow in 25 the pipeline.

Further optional features of the invention are set out in the accompanying sub-claims.

30

In order that the invention may be more fully understood, several embodiments in accordance with the invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figures 1 to 3 schematically show three different embodiments in accordance with the invention within a pipeline; and

5 Figures 4 and 5 show respectively a perspective view and an axial section of part of the arrangement of Figure 1.

Various tractor arrangements for movement along a pipeline within a fluid flow are described in Patent Publications WO 98/06927, WO 00/73619 and WO 01/18351, 10 and similar arrangements may be used with appropriate modifications in accordance with the invention. Such modifications involve regulation of the speed at which the tractor is propelled along the pipeline such that the tractor speed is not directly related to the speed of the fluid flow, and is preferably substantially independent of the speed of the fluid flow, as described in more detail below. It should be understood that the 15 arrangements described in these prior publications are incorporated herein by reference.

In a first embodiment of the invention, shown diagrammatically in Figure 1, a tractor module 10 is coupled at opposite ends to a cleaning or inspection module 11 and a power generation module 12, the three modules being arranged in line within the 20 pipeline 14 such that traction elements 15 on the tractor module 10 engage the wall of the pipeline 14. The flow of fluid along the pipeline 14 is indicated by an arrow 16, whereas the direction of travel of the tractor is indicated by the arrow 17. In operation within the pipeline drive is imparted to the power generation module 12 by the fluid flow, and the tractor module 10 is driven by the power generation module 12 by way of 25 a coupling 18 and appropriate step-down gearing (not shown). Power may also be supplied to the cleaning or inspection module 11 by the tractor module 10 or the power generation module 12 by way of a further coupling 19.

The tractor module 10 is shown in more detail in Figure 4 from which it will be 30 seen that the module comprises a generally cylindrical housing 22, the power generation module 12 incorporating a turbine 23 having a cylindrical sleeve 24 which is mounted on the housing 22 coaxially with a drive shaft 21. The sleeve 24 provides mounting for

a number of magnets 26 which interact with opposite pole magnets 28 mounted on a flywheel 30 within the housing 22, as may be seen in the axial section of Figure 5. The magnets 26, 28 are arranged to provide inductive coupling through an intervening non-magnetic body portion. Thus the magnets 26, 28 provide a contactless coupling and

5 avoid the need to provide seals and the like between the turbine 23 and the housing 22. The flywheel 30 is coupled to a gearbox 25, which is in the form of a harmonic drive. Alternatively drive may be imparted from the turbine 23 to the drive shaft 21 by way of a direct drive gearbox. For example the turbine 23 may have a gear wheel on its inner diameter which drives gear wheels protruding through the wall of the housing 22. In

10 this event seals at either end of the turbine allow the turbine bearings to be lubricated and not exposed to the fluid in the pipeline.

A speed governor is used to control the rotational speed of the drive shaft 21 or a traction wheel. For example a brake type centrifugal governor may be used to control

15 the speed. In this case a brake shoe is used as the flyweight and restrained by a spring force. As the speed is increased the brake shoe comes into contact with the housing and slows the drive shaft down.

The traction module 10 includes a plurality of traction elements 22 each of

20 which comprises a bush from which resilient fingers 50 extend, the bush being mounted on an off-axis bearing 48 such that rotation of the axial shaft 21 causes the fingers 50 to be oscillated backwards and forwards relative to the pipeline wall as described in WO 98/06927. Such oscillation of the fingers 50 varies the traction provided by the traction elements such that the tractor module 10 is propelled along the pipeline by the contact

25 of the fingers 50 with the wall of the pipeline. By moving of the fingers 50 from one side of the bearing centre line to the other it is possible to reverse the direction of traction, to facilitate movement of the tractor in the opposite direction to the original drive direction.

30 In operation of such an arrangement the tractor is launched from the wellhead, or from an upstream position, into the pipeline in a similar manner to a conventional pig. However the power generation module 12 is driven by the fluid flow in the pipeline to

generate power, and this power is then used to operate the tractor module 10 so that the tractor module 10 is positively driven in the direction of travel, rather than simply relying on pressure of the fluid flow to propel the tractor along the pipeline. Thus, because the tool is caused to travel along the pipeline at a controlled rate, the speed of 5 propulsion is not dictated by the speed of fluid flow in the pipeline. Furthermore the power generated within the power generation module 12 may be used to operate auxiliary modules, such as the cleaning or inspection module 11, and may also enable power to be stored for alternative use. The speed of travel of the tractor module 10 is controlled by a speed governor or electronic speed control.

10

The traction elements of the tractor module 10 may alternatively be brush-type traction elements as used in the embodiments of Figures 3, 4a, 4b and 4c of WO 98/06927, in which case the brushes may be positioned to brake the module against the fluid pressure whilst allowing the traction module 12 to be propelled forwardly at a 15 controlled rate by the power supplied by the power generation module 12.

Figure 2 shows a further embodiment of the invention in which the same reference numerals are used to denote similar parts as in Figure 1. In this case two tractor modules 60 and 61 are coupled back-to-back by a mesh braking gear 62 and 20 reduction gearing, each of the modules 60 and 61 incorporating traction elements in the form of rollers 63 for engaging the wall of the pipeline 14 to impart traction in the manner described with reference to Figures 3, 4a, 4b and 4c of WO 98/06927. As a result of the arrangement of the traction elements on the tractor modules 60 and 61 and the coupling mesh gear 62, the tractor modules 60 and 61 are rotated in different 25 directions and at different speeds, and this causes braking of the travel of the tractor so as to ensure that the tractor travels along the pipeline at a controlled speed substantially independent of the speed of fluid flow along the pipeline.

Figure 3 shows a still further embodiment of the invention in which similar parts 30 are denoted by the same reference numerals as in Figures 1 and 2. In this case the tractor module 70 comprises a body 71 having sprung members 72, and a wheel 73 for bearing against the wall of the pipeline to maintain the wheel 73 in rolling engagement

with the pipeline wall. In this case the drive to the wheel 73 may be directed by way of gearing from a spinning device driven by the power generation module 12, or alternatively the wheel 73 may be braked by hydraulic, mechanical, magnetic or electrical means so as to control the speed of travel of the tractor.

5

The embodiments of Figures 1 and 3 provide a large bypass area by means of which the fluid flow within the pipeline may pass beyond the tractor, and this is advantageous in assisting controlled driving of the tractor independently of the speed of fluid flow. The embodiment of Figure 2 has channels machined along the length of the 10 body to increase the flow area past it.

The above described embodiments of the invention possess a number of advantages in practice in that they generate power from the fluid flow in the pipeline and use this power for controlled driving of the tractor independently of the pressure of 15 the fluid imparting drive. This enables the speed of inspection operations to be regulated and/or more effective cleaning operation. The invention solves the problem of the intermittent travel of conventional pigs along a pipeline by using a tractor as a speed regulator so that the force of the fluid in the pipeline does not directly control the speed of travel. The pressure drop across the tool is significantly less than that across a 20 conventional pig so that the pressure force pushing the tool is significantly less than in conventional pigging operation.

Various modifications of the above described embodiments are possible within the scope of the invention. For example the cleaning or inspection module may be 25 provided with its own dedicated power unit for generating the power required for the module from the fluid flow. Furthermore, when the arrangement is used for cleaning, an additional scrubbing unit may be incorporated to ensure better cleaning.

30

CLAIMS:

1. A tractor for movement along a pipeline within a fluid flow along the pipeline, the tractor comprising propulsion means for propelling the tractor along the pipeline in the direction of the fluid flow at a speed which is not directly related to the speed of the fluid flow.
5
2. A tractor for movement along a pipeline within a fluid flow along the pipeline, the tractor comprising speed regulated propulsion means for propelling the tractor along the pipeline in the direction of fluid flow at a regulated speed.
10
3. A tractor according to claim 1 or 2, wherein the propulsion means includes speed regulating means for regulating the speed at which the tractor is propelled along the pipeline to a speed which is substantially independent of the speed of the fluid flow.
15
4. A tractor according to claim 3, wherein the speed regulating means incorporates braking means for braking the tractor by engagement with a wall of the pipeline.
5. A tractor according to claim 2 or 3, wherein the speed regulating means incorporates a speed governor for controlling the speed at which traction means engaging a wall of the pipeline is driven.
20
6. A tractor according to any preceding claim, wherein the propulsion means is driven by driving means adapted to be driven by the fluid flow.
25
7. A tractor according to claim 6, wherein the driving means is a turbine.
8. A tractor according to claim 6 or 7, wherein the driving means is coupled to the propulsion means by conversion means which is adjustable to vary the degree of coupling between the propulsion means and the drive means.
30

9. A tractor according to claim 8, wherein the conversion means comprises a magnetic coupling.
10. A tractor according to claim 9, wherein the coupling comprises driving and driven elements which are relatively axially movable.
11. A tractor according to claim 8, 9 or 10, wherein the conversion means comprises reduction gearing for converting a high speed low torque input from the propulsion means to a relatively low speed high torque output to the drive means.
12. A tractor according to claim 8, 9, 10 or 11, wherein the conversion means comprises a harmonic drive.
13. A tractor according to any preceding claim, wherein the propulsion means incorporates a plurality of traction elements for engaging a wall of the pipeline, and drive means for driving the traction elements to move the tractor along the pipeline.
14. A tractor according to claim 13, wherein the traction elements are wheels which are driven in rolling engagement with the wall of the pipeline.
15. A tractor according to claim 13, wherein the traction elements are outwardly extending legs or brushes which are driven backwards and forwards relative to the wall of the pipeline to effect propulsion of the tractor in the required direction along the pipeline.
16. A tractor according to claim 15, wherein the traction elements are mounted on eccentric bearing means.
17. A tractor according to any one of claims 13 to 16, wherein the drive means comprises a rotatable shaft extending generally axially within the pipeline.

18. A tractor according to any one of claims 13 to 17, wherein braking means are provided for braking the traction elements in order to control the rate at which the tractor is propelled along the pipeline.

5 19. A tractor according to claim 18, wherein the braking means comprises a disc braking system.

10 20. A tractor according to any one of claims 13 to 19, wherein the propulsion means incorporates two traction units incorporating traction elements for engaging the wall of the pipeline and adapted to be driven by the drive means such that the traction units are biased to act in opposite directions.

15 21. A tractor according to claim 20, wherein control means are provided for controlling the rate at which the traction elements of the two traction units are driven relative to one another so as to regulate the speed at which the tractor is propelled along the pipeline.

22. A tractor according to any preceding claim, wherein a fluid bypass is provided for permitting fluid flow along the pipeline past the tractor.

20

23. A tractor according to any preceding claim, wherein cleaning means is provided for removing or dislodging material from a wall of the pipeline.

25 24. A tractor according to any preceding claim, wherein jetting means is provided to direct jets of fluid onto a wall of the pipeline for removing or dislodging material from the wall.

25 25. A tractor according to any preceding claim, wherein cutting means is provided for removing or dislodging material from a wall of the pipeline.

30

26. A tractor according to any preceding claim, wherein inspection means is provided for inspecting a wall of the pipeline.

27. A tractor for movement along a pipeline within a fluid flow along the pipeline, the tractor incorporating a geared braking mechanism for controlling the speed of the tractor along the pipeline in the direction of fluid flow.

5

28. A tractor for movement along a pipeline within a fluid flow along the pipeline, the tractor being substantially as hereinbefore described with reference to the accompanying drawings.

10

ABSTRACT**" Tractors for Movement along a Pipeline within a Fluid Flow "**

5 A tractor comprises a tractor module 10 coupled at opposite ends to a cleaning or inspection module 11 and a power generation module 12, the three modules being arranged in line within a pipeline 14 such that traction elements 15 on the tractor module 10 engage the wall of the pipeline 14. In operation within a pipeline along which fluid is flowing in the direction 16, drive is imparted to the power generation 10 module 12 by the fluid flow, and the tractor module 10 is driven in the direction 17 by the power generation module 12 by way of a drive shaft 21 and appropriate step-down gearing (not shown). A speed governor is used to control the rotational speed of the drive shaft 21 such that the tractor speed is not directly related to the speed of the fluid flow, and is preferably substantially independent of the speed of the fluid flow. A 15 tractor travelling at a constant and/or controlled speed is found to achieve better cleaning, or to enable more efficient inspections, than a tractor which is propelled along the pipeline at the rate of fluid flow in the pipeline.

1/2

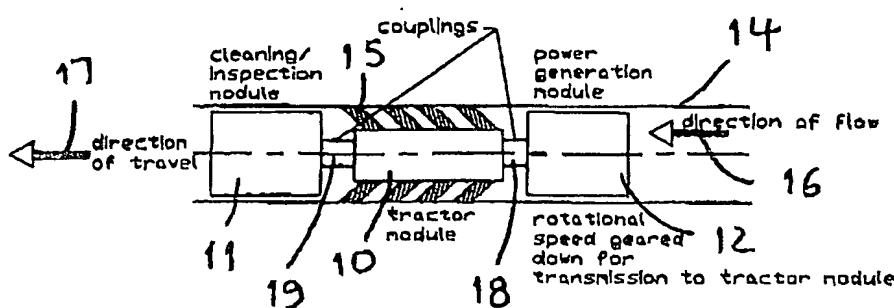


Figure 1

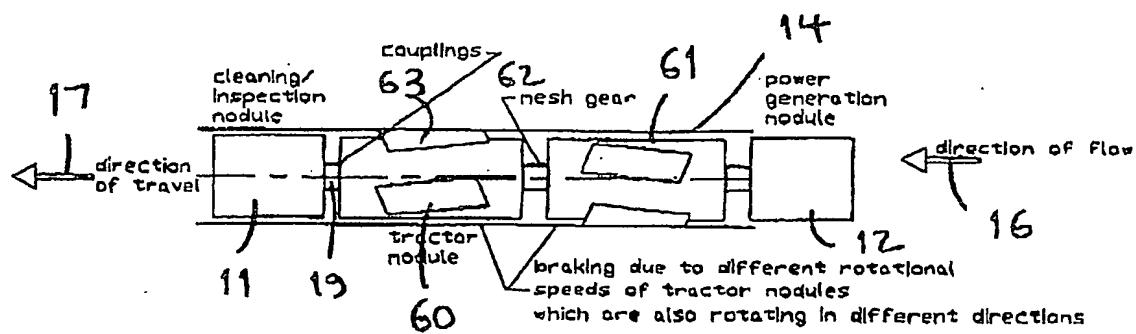


Figure 2

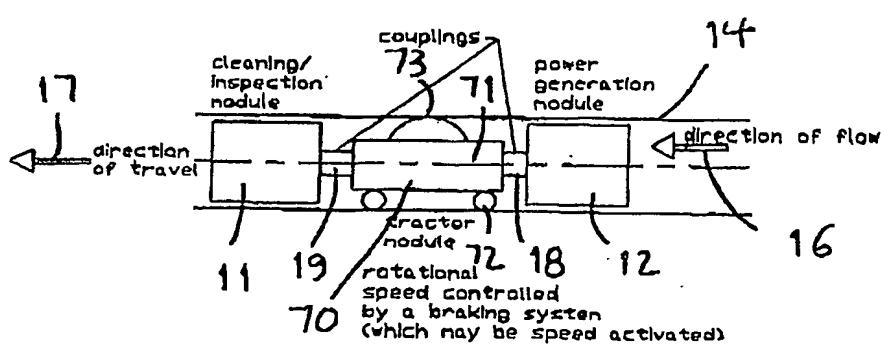


Figure 3

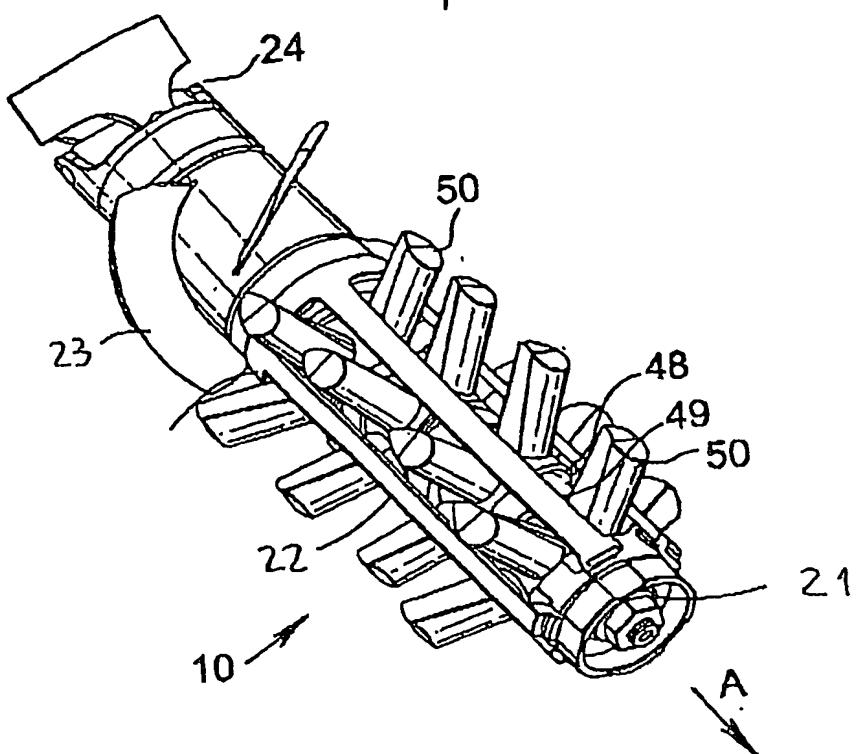


Fig. 4-

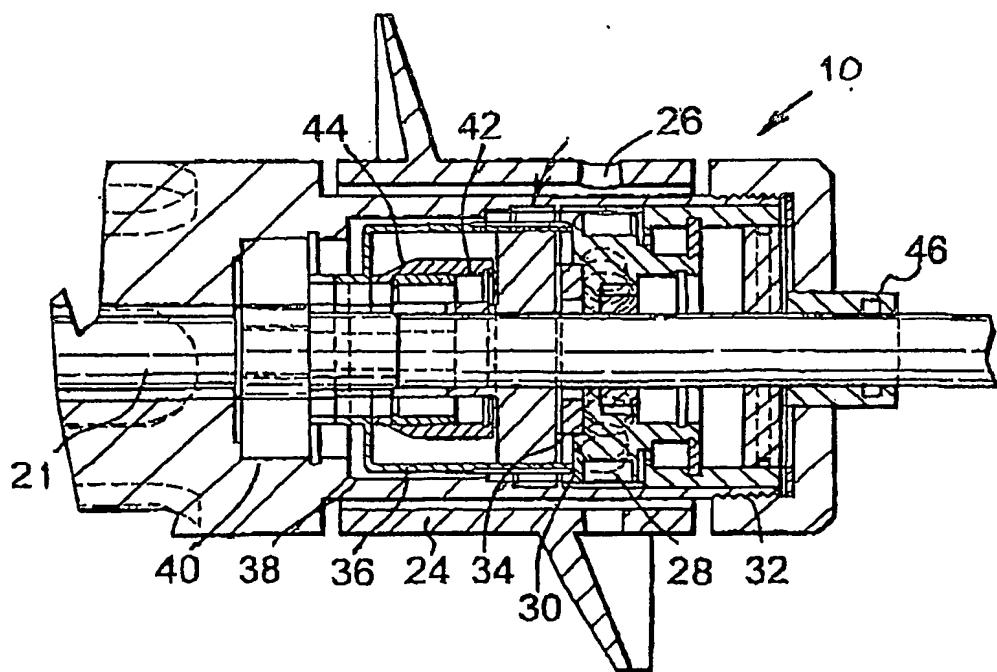


Fig. 5

**This Page is Inserted by IFW Indexing and Scanning
Operations and is not part of the Official Record**

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- BLACK BORDERS**
- IMAGE CUT OFF AT TOP, BOTTOM OR SIDES**
- FADED TEXT OR DRAWING**
- BLURRED OR ILLEGIBLE TEXT OR DRAWING**
- SKEWED/SLANTED IMAGES**
- COLOR OR BLACK AND WHITE PHOTOGRAPHS**
- GRAY SCALE DOCUMENTS**
- LINES OR MARKS ON ORIGINAL DOCUMENT**
- REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY**
- OTHER:** _____

IMAGES ARE BEST AVAILABLE COPY.

As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.